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# BRIEF DESCRIPTION
OF THE
# ANTHRACITE COAL FIELDS
# OF PENNSYLVANIA.

BY

CHARLES A. ASHBURNER, M.S.,

*Geologist in Charge of the Anthracite Survey.*

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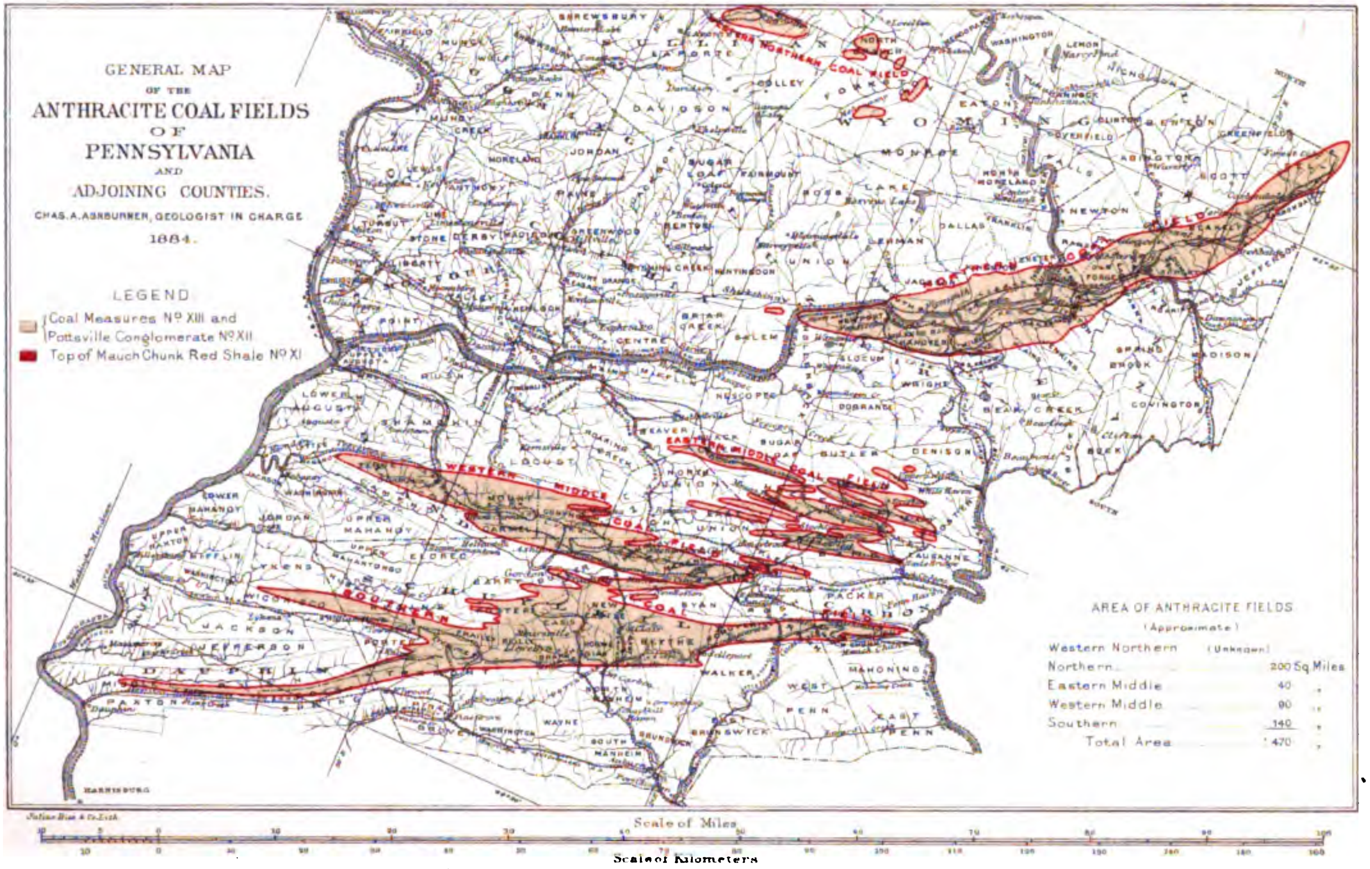

GENERAL MAP
OF THE
ANTHRACITE COAL FIELDS
OF
PENNSYLVANIA
AND
ADJOINING COUNTIES.
CHAS. A. ASHBURNER, GEOLOGIST IN CHARGE
1884.

LEGEND

▨ {Coal Measures Nº XIII and Pottsville Conglomerate Nº XII
🟥 Top of Mauch Chunk Red Shale Nº XI

AREA OF ANTHRACITE FIELDS
(Approximate)

| | | |
|---|---|---|
| Western Northern | (Unknown) | |
| Northern | 200 | Sq. Miles |
| Eastern Middle | 40 | " |
| Western Middle | 90 | " |
| Southern | 140 | " |
| Total Area | 470 | " |

MAY 28 1901

# BRIEF DESCRIPTION OF THE ANTHRACITE COAL FIELDS OF PENNSYLVANIA.

By Charles A. Ashburner, Member of the Club.

*Read by Title, June 21st, 1884.*

## GEOGRAPHY.

The anthracite region is situated in the north-eastern part of Pennsylvania, between the Washington meridian and that 1° 10′ east and the north parallels of 40° 25′ and 41° 40.′

It is divided into the following prominent divisions: (1) Southern or Pottsville Field, extending from the Lehigh River at Mauch Chunk, south-west to within a few miles of the Susquehanna River, directly north of Harrisburg, and embraced by Carbon, Schuylkill and Dauphin Counties. The eastern end of this field, known as the Lower Lehigh or Panther Creek basin, between Tamaqua on the Little Schuylkill River and Mauch Chunk, has generally been included by the coal trade in the Lehigh Field, from the fact that its coals resemble more closely the coals obtained in the Upper Lehigh region than those in the Pottsville Field west of Tamaqua, and since the shipments to market have almost entirely been made through the Lehigh Valley. (2) Western Middle or Mahanoy and Shamokin Field, lying between the eastern-most head-waters of the Little Schuylkill River and the Susquehanna River and within Schuylkill, Columbia and Northumberland Counties. These two coal fields (1 and 2) are frequently designated in a general way as the Schuylkill region, although parts of them are better known to the trade by names defining districts from which coals of special characteristics are

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Notes.—This brief description was prepared by the author for the Proceedings of the Club in anticipation of the excursion through the Anthracite region, on September 6th, 1884, tendered by the Philadelphia and Reading and Lehigh Valley Railroads to the members of the American Institute of Mining Engineers, American Association for the Advancement of Science, British Association for the Advancement of Science, and other foreign societies. Reference has only been made to those features which, it was thought, would be of especial interest on this occasion.

The black base of the accompanying map was printed from an engraved stone in the possession of the Second Geological Survey, by permission of the Board of Commissioners.

mined. (3) Eastern Middle, or Upper Lehigh Field, lying between the Lehigh River and Catawissa creek and principally in Luzerne County, with limited areas extending into Carbon, Schuylkill and Columbia Counties. (4) Northern or Wyoming and Lackawanna Field, lies in the two valleys from which it derives its geographical names, and is embraced almost entirely by Luzerne and Lackawanna Counties. A small area in the extreme north-eastern end of the field extends into Wayne and Susquehanna Counties. (5) Loyalsock and Mehoopany Field,* lies within the area drained by the head-waters of the Loyalsock and Mehoopany creeks, and is contained in Sullivan and Wyoming Counties. This field is from twenty to twenty-five miles north-west of the western end of the Northern Field. Its geological structure resembles more closely that of the bituminous field, in which it has until recently been included, although the composition of many of its coals entitles them to rank with a number from the anthracite region.

The area of the region is about 1700 square miles. The natural geological and topographical boundaries of this area are formed by the mountains and ridges made by the Pocono sandstone No. X; although, no workable coal beds have been found stratigraphically below the Pottsville conglomerate No. XII, the Lykens Valley or lowest anthracite beds being found in the latter formation. The greatest length of the region, from the north-eastern end of the Northern Field to the south-western end of the Southern Field, is about 115 miles, while the greatest width of the belt, containing the first four fields, is about 30 miles between Mauch Chunk and Shickshinny, near the western end of the Northern Field.

The approximate areas underlaid by workable beds in the different fields are as follows:

| | | | |
|---|---|---|---|
| Northern | 200 | square | miles. |
| Eastern Middle | 40 | " | " |
| Western Middle | 90 | " | " |
| Southern | 140 | " | " |
| Loyalsock and Mehoopany | Unknown. | | |
| Total | 470 | " | " |

---

* It has been suggested that this field be called the Western Northern (See map).

## HISTORY.

The first record we have of the practical use of Pennsylvania anthracite is in 1768 and 1769, when it was employed for blacksmithing by two brothers named Gore, who had moved from Connecticut and settled in the Wyoming Valley near Wilkes Barre. This was possibly twenty years subsequent to the commencement of coal mining in the United States, in the Mesozoic bituminous basin in the vicinity of Richmond, Virginia.

In 1775 it is reported that a cargo of coal was shipped in flatboats from Wilkes Barre down the Susquehanna to the government armory at Carlisle.

The first organized effort for the mining of coal was in 1793, when the Lehigh Coal Mine Company was organized, and purchased land at Summit Hill, nine miles from Mauch Chunk, from Mr. J. Weiss. The Mammoth bed had been accidently discovered on this land in 1791. In 1803, this company loaded six flat-boats or river-arks, holding about 10 tons each, and started them down the Lehigh River for Philadelphia; only two of these boats reached destination. No one knew how to burn the stone-coal and it was considered worthless. In 1814 another shipment of five arks was made in the same way, two of them reaching Philadelphia, the coal which they contained being sold to White & Hazard at the Falls of the Schuylkill. This latter shipment was preceded two years (1812) by nine wagon-loads of coal, hauled to Philadelphia from the Schuylkill region.

It appears that Judge Fell, of Wilkes Barre, first used anthracite coal as a household fuel. In a memorandum dated Feb. 11th, 1808, he says, "made the experiment of burning the common stone-coal of the valley, in a grate, in a common fire-place in my house, and find it will answer the purpose of fuel, making a clearer and better fire at less expense than burning wood in the common way."

The first use of anthracite, in connection with the manufacture of iron, dates from 1812, when White & Hazard purchased one of the nine wagon-loads from the Schuylkill region at the cost of transportation, and successfully used the coal in heating the furnace of their nail and wire mill at the Falls of the Schuylkill.

The regular shipment of anthracite coal to market, however, did not commence until 1820, during which year the Lehigh Coal and Navigation Company sent 365 tons from their famous mine at Summit Hill to Philadelphia. In 1822 the Schuylkill region is reported to have first shipped to market 1480 tons. In 1829, 7000 tons were first shipped from the Wyoming region by the Delaware and Hudson Canal Company, whose canal had just been completed; the aggregate shipment from the entire region during the latter year being 112,083 tons.

Anthracite for the generation of steam was first employed in January, 1825, under the boiler of Thompson's rolling mill at Phœnixville.

The first successful use of anthracite, as an exclusive fuel in the blast furnace, was at the Pioneer furnace, built during 1837 and 1838 at Pottsville by William Lyman, of Boston. The first successful blast was blown in at this furnace on October 19th, 1839. In recognition of the results obtained in this furnace, Mr. Lyman was paid a premium of $5,000 by Nicholas Biddle and others, as being the first person in the United States who had made anthracite pig iron continuously for one hundred days. As early as 1824 attempts had been made to use anthracite in charcoal furnaces, mixed with charcoal; this and many subsequent attempts prior to 1839 seem to have all met with failure. On July 3d, 1840, Mr. David Thomas successfully blew in a furnace which he had built for the Lehigh Crane Iron Company at Catasauqua, on the Lehigh River. Previous to this time Mr. Thomas had been associated with Mr. Crane in his experiments at Yniscedwin. The Catasauqua furnace was in active operation until 1879, when it was torn down.

The First Geological Survey of this region by the State, was commenced in 1836, and was continued at intervals until the publication of the final Report of the First Survey in 1858. The results of this survey were in the highest sense valuable; they are being supplemented, rather than replaced, by the more detailed and practical work of the Second Survey.

The Second Survey was commenced in August, 1880, and has been vigorously prosecuted since that time. The principal object of this Survey has been to make the results practically useful to those directly interested in the exploration and exploitation of the coal fields. About one-third of the area of the region has been mapped by the survey, although the work cannot be said to be one-third completed, since the geology of the area not yet examined and surveyed is more difficult and less developed than that of the area already covered.

These few facts connected with the early history and development of anthracite coal are interesting, when it is considered that the mining and transportation of Pennsylvania anthracite is the most important industry connected with the development of any mineral, in any one State in the Union.

## TOPOGRAPHY.

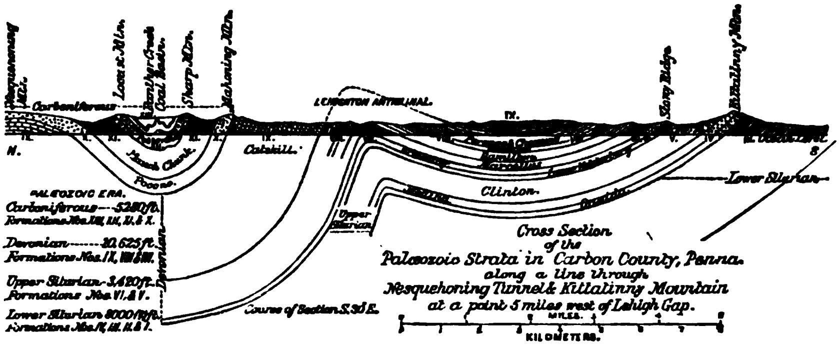
The grand features of the topography of the region have been determined by its structural geology. These consist of two distinct series of ridges or mountains, one formed by the Pottsville conglomerate, and the other by the Pocono sandstone; and two series of valleys, that eroded out of the coal measures, surrounded by the Pottsville conglomerate ridges, and that cut out of the Mauch Chunk red shale No. XI, which lies between the two series of ridges. The Pottsville conglomerate mountains rise from eight hundred to one thousand feet above their bases, while the Pocono mountains are generally, though not always, higher. The difference between the extremes of elevation within a radius of twenty-five miles rarely exceeds fifteen hundred feet, while that between the extremes within a compass of two or three miles seldom amounts to more than one thousand feet. In speaking of these grand features, Professor Lesley says, "Each coal basin is set in a double frame, being limited by a mountain of conglomerate, outside of which runs a narrow valley or trough of red shale, outside of which again runs a second and still higher mountain of white sandstone, the outside flank of which is always furnished with a terrace of red sandstone." The surface of the valleys underlaid by the coal measures is undulated by small ridges, which are formed by the harder sandstones contained in the intervals between the coal beds. The coal beds themselves frequently form terraces along the slopes of the ridges, which permit of the coal beds being easily traced, in many localities over considerable areas. The most prominent of these ridges seldom rise to a height more than half of that of the enclosing Pottsville conglomerate mountains. The Broad Mountain plateau, separating the Western Middle and Southern Fields, and ranging about five miles wide and fifteen miles long, the Upper Lehigh Mountain plateau, containing the coal basins of that region, and ranging about eight miles wide and fifteen to twenty miles long, and the Nescopec Mountain plateau, which crosses the Lehigh Valley and Lehigh and Susquehanna Railroads between White Haven and the southern rim of the Wyoming Valley, are exceptions to the usual sharp profiles of the Pottsville and Pocono mountains. A general idea of the height of the region and surrounding areas above ocean level may be had from the following elevations of prominent points:

| | | | |
|---|---|---|---|
| Harrisburg (P. R. R. depot) . . . | 321 | Tamaqua (P. & R. R. R. depot) . | 803 |
| Northumberland . . . . . . . . | 452 | Mahanoy City . . . . . . . . | 1343 |
| Catawissa . . . . . . . . . . . | 477 | Shenandoah . . . . . . . . . . | 1252 |
| Shickshinny . . . . . . . . . . | 521 | Gilberton (P. & R. R. R. depot) . | 1133 |
| Nanticoke . . . . . . . . . . . | 538 | Ashland . . . . . . . . . . . . | 859 |
| Wilkes Barre (L. & S. R.R. depot) | 550 | Mount Carmel . . . . . . . . . | 1054 |
| Pittston (L. V. R. R. depot) . . | 571 | Shamokin (P. & R. R. R. depot) . | 738 |
| Scranton (D. L. & W. R. R. depot) | 739 | Mauch Chunk (L. V. R. R. depot) | 544 |
| Port Clinton . . . . . . . . . | 410 | Hazleton (L. V. R. R. depot) . . | 1612 |
| Schuylkill Haven . . . . . . . | 526 | Drifton (L & S. R. R. depot) . . | 1633 |
| Pottsville . . . . . . . . . . . | 614 | White Haven (L. V. R. R. depot) | 1143 |
| Tremont . . . . . . . . . . . | 766 | Upper Lehigh . . . . . . . . | 1802 |

## STRUCTURAL GEOLOGY.

All the rocks found in, or immediately surrounding the anthracite region, are sedimentary, belong to the Palæozoic era, and are highly corrugated. These strata, which after their deposition were comparatively horizontal, have been thrown into the deformations, in which we now find them, by the secular cooling and consequent contraction of the earth's surface, after the close of the Palæozoic time. The prominent features in the structure of this portion of the State are illustrated by the accompanying vertical cross-section (Fig. 1).

FIG. 1.



The denudation of the surface of the region by the natural eroding agents, which are still at work in a greater or less degree, has been very great, after the strata were upheaved and corrugated. From the top of Kittatinny mountain has been cut away all the strata included between the Medina sandstone (part of No. IV) and the highest coal measures (part of No. XIII) in the Panther Creek basin, measuring in the aggregate over 18,000 feet, perpendicular to the bedding. If the dip of the strata, after the corrugation was effected and before denudation had perceptibly taken place, was the same along a vertical line through the mountain as it is now, then as much as four miles vertical thickness of strata have been eroded from the area now marked by the Kittatinny crest. This mountain is one of the boldest topographical features in the State. It extends from the Delaware Water gap, between New Jersey and Pennsylvania, southwest for 90 miles to a point in Franklin County twelve miles west of Chambersburg. The details of the structure, between that portion of the mountain,* included between the Lehigh and Susquehanna Rivers and Sharp Mountain, formed by the Pottsville conglomerate, No. XII, which skirts the southeastern limit of the Southern Field, is different in many places from that shown in the accompanying section; the general structure, however, varies little.

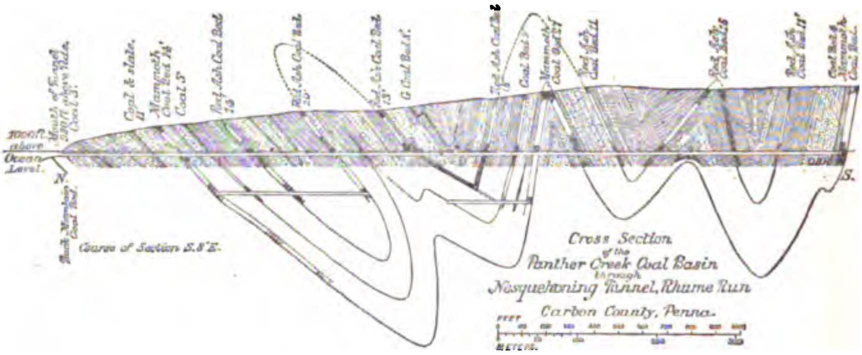
The northern end of the section through the Panther Creek coal basin has been enlarged (from scale of 3 miles to 1 inch,

---

* Approximately defined by the lower border line of the accompanying map.

$\frac{1}{190080}$ths of nature to a scale of 800 feet to 1 inch, $\frac{1}{9600}$ths of nature) to illustrate some of the details of the structure of the anthracite basins (Fig. 2).*

FIG. 2.



The Pottsville conglomerate (No. XII), underlying the productive coal measures, has been thrown into broad, regular, and generally symmetrical flexures, while the overlying softer measures, containing all the workable coals, except in those districts where the Lykens Valley beds have dimensions sufficient to be mined, are found conformable to subordinate flexures of three kinds: symmetrical (central anticlinal, Fig. 2), unsymmetrical (southern anticlinal), and reversed (northern isoclinal).† In the case of the unsymmetrical and reversed flexures, the plane passing through the axes of the flexures, as exhibited in the different strata, is generally inclined down and toward the area of maximum disturbance.

---

* The method which has been used for representing the coal beds and rock strata in this section is that which has been adopted by the author for the cross-sections of the Geological Survey, as follows: (1) Where a coal bed has been worked out in the plane of section it is shown by two lines, one at the top and the other at the bottom of the bed; (2) where the position of a coal bed is certainly known, but the coal has not been worked out in the plane of section, it is shown by a heavy black line; (3) where the position of a coal bed can only be approximately determined, with present available facts, it is indicated by a single line representing the bottom of the bed; (4) the rock strata are only shaded where their character is absolutely known. One of the primary objects of the Anthracite Survey has been to render the results of its work of practical utility, and this method of constructing the cross-sections renders them of the greatest value to those superintending the mining of coal.

† Through the region an isoclinal, or a flexure, where the strata appear to dip in one direction on either side of the axis, is generally called an overturn, or overturned anticlinal.

This area of maximum disturbance lies to the south-east of the anthracite region, in the vicinity of Kittatinny mountain and is co-extensive with it throughout the central part of the State, crossed not only by this Medina crest, but by the parallel mountains capped by the same formation, and constituting what are known as the Blue ridges* in Pennsylvania and the North mountains in Virginia. This inclining of the unsymmetrical and reversed flexures toward the north and north-west was formerly thought to be universal in the anthracite region; recently, however, a number of exceptions have been found in small anticlines and isoclines, which incline toward the south and south-east. In the case of the accompanying sections, the Lehighton anticlinal (Fig. 1) and Panther Creek isoclinal (Fig. 2) follow the general law of inclination.

The area of maximum folding and contortion of the coal bearing measures is in the Southern Field, where the occurrence of isoclinals and sharp, narrow anticlinals and synclinals is more frequent. In the other fields the flexures gradually become flatter, broader, and further apart toward the north-west. The structure in the Eastern Middle Field is an apparent exception: when it is remembered, however, that in this district the flexures in the coal measures are found at a much greater height above ocean level, and the coal basins are generally much shallower than in the Southern Field, the general conclusion holds true, for the most complicated structure is invariably found in the bottoms of the coal basins, where the squeezing of the strata was the greatest during the original plication.†

---

* The structure of these mountains and ridges is illustrated by numerous cross-sections constructed by the author in 1874 and '75 and contained in Report F, Sec. Geol. Sur. of Pa.

† The difficulties which have been encountered in mining near and in the bottoms of the Lehigh basins, foreshadow the greater irregularities of structure, which will probably be met with in mining in the bottoms of the Southern Field basins. Although the details of structure are rarely duplicated in different districts, yet I believe a careful mapping and study of the structural geology of the Lehigh basins will aid materially in the most economical development of the deeper portion of Southern Field basins.

The Northern Field, which is further removed from the area of maximum disturbance, is composed of a broad, canoe-shaped basin with moderate dips, the surface of any one of the coal measure strata, in general, being but slightly undulated by broad, low anticlinals and shallow synclinals, while the structure of the Loyalsock and Mehoopany Field,* which is still further removed, is identical with that of the Pennsylvania bituminous field; the average maximum dips of the coal bed ranging from between 3 and 5 feet to 100 feet.

Some idea may be had, from the following table, of the depths of some of the anthracite basins in which information has been obtained, of a sufficiently definite character, to permit of estimates being made. The elevations are given in feet above ocean level:

### NORTHERN FIELD, WILKES BARRE BASIN.

| | FEET. |
|---|---|
| Wilkes Barre (L. V. R. R. depot), . . . . | +549 |
| Mammoth bed outcrop on north side of basin, at Kingston Coal Company's slope, No. 2, . . | +788 |
| Mammoth bed outcrop on south side of basin, at Hollenback slope, No. 2, . . . . . | +774 |
| Bottom of Mammoth bed basin under flat, north of Wilkes Barre (estimated), . . . . . | — 800 |
| Depth attained by workings at Prospect colliery, . | — 300± |
| Width of basin, 23,200 feet (4.4 miles). | |

### EASTERN MIDDLE FIELD, DRIFTON BASIN.

| | |
|---|---|
| Drifton (L. and S. R. R. depot), . . . . . | +1633 |
| Buck Mountain bed outcrop on north side of basin, at Drifton slope, No. 2, . . . . . . | +1692 |
| Buck Mountain bed outcrop on south side of basin, | +1645 |
| Bottom of Buck Mountain bed basin, . . . | +1150 |
| Width of basin, 2,250 feet (.4 miles), . . . | |

### HAZLETON BASIN.

| | |
|---|---|
| Hazleton (L. V. R. R. depot), . . . . . | +1612 |
| Mammoth bed outcrop on north side of basin, . | +1660 |

---

* This field has been provisionally named, on the map, the Western Northern.

| | |
|---|---|
| Mammoth bed outcrop on south side of basin, at Hazleton slope, No. 6, . . . . . . | +1672 |
| Bottom of Mammoth bed basin, . . . . . | + 850 |
| Width of basin along line through slope, No. 6, 3,800 feet (.7 miles). | |

### WESTERN MIDDLE FIELD, MAHANOY BASIN.

| | |
|---|---|
| Gilberton (P. and R. R. R. depot), . . . . | +1133 |
| Mammoth bed outcrop on north side of basin, at Gilberton slope, . . . . . . . . | +1223 |
| Mammoth bed outcrop on south side of basin, at Draper slope, . . . . . . . . . . | +1275 |
| Bottom of Mammoth bed basin, (estimated) . . | — 150 |
| Width of basin along line through Gilberton slope, 3,050 feet (.6 miles). | |

### SOUTHERN FIELD, PANTHER CREEK BASIN.

(Near Tamaqua.)

| | |
|---|---|
| Tamaqua (P. and R. R. R. Depot), . . . . | + 803 |
| Mammoth bed outcrop on north side of basin, . | +1250± |
| Mammoth bed outcrop on south side of basin, . | +1300± |
| Bottom of Mammoth bed basin, (estimated) . . | —1000 |
| Width of basin, 5,700 feet (1.1 miles). | |

The region is exceptionally free from rock faults. No downthrow or upthrow faults have been defined, such as are so frequently met with in the English coal field, where the hade of the fault makes an angle of more than 90 degrees with any one stratum on either side of the fault plane. The only breaks in the strata, which are worthy of mention in this brief description, are the fractures which occur along the reversed flexures, and which are properly called reversed faults. When the strata were corrugated and the overturns formed, the tension of the strata along the axis of the isoclinal was so great, that those on the upper side of the axial plane were shoved past those on the lower side;* these faults seldom amount to more than 300 or 400 feet, and in most cases where coal beds are enclosed in the faulted strata, the coal beds have been continued along the fractu or fault plane, but generally in a dirty, unworkable conditi Such faults have been encountered in the vicinity of Shenando and along the south side of Bear Ridge, in Schuylkill Coun and in the vicinity of Hazleton, Plymouth and Wilkes Barre, Luzerne County.

---

* Faults of this character are illustrated, in the case of the Alps, by Heim, in his work on Mountain-making.

## STRATIGRAPHICAL GEOLOGY.

The rocks outcropping in the region are stratified and w deposited during the Palæozoic era.

The thicknesses of the several formations vary considerab along their outcrop in different portions of the field; their lit logical characteristics are sufficiently constant, however, to perr of an easy recognition by the experienced geologist where they are exposed. The names of the periods and epochs un which these strata have been commonly grouped, with th accompanying thicknesses, as determined by the Geologi Survey along the Lehigh River in Carbon County, south of eastern end of the Southern Field (Fig. 1), are exhibited in following table:

### PALÆOZOIC ERA.

#### I. Carboniferous Period.

| | | | FEET. |
|---|---|---|---|
| XIII. | Productive Coal Measures, . . . . | | 975 |
| XII. | Pottsville Conglomerate (Seral, Millstone Grit), | | 880 |
| XI. | Mauch Chunk Red Shale (Umbral), . . | | 2170 |
| X. | Pocono Sandstone and Conglomerate (Vespertine), . . . . . . . . | | 1255 |

#### II. Devonian Period.

| | | | |
|---|---|---|---|
| IX. | Catskill Sandstone (Ponent) . . . . | | 7145 |
| VIII. | Chemung Shales and Sandstones,<br>Portage Shales and Flags, | Vergent | 1290 |
| | Genesee Slates and Shales, | Cadent | 290 |
| | Hamilton Sandstones and Flags, | | 760 |
| | Marcellus Shales and Slates, | | 800 |
| | Upper Helderberg Limestone,<br>Caudi Galli and Schoharie Grits, | Post Meridian. | Abse |
| VII. | Oriskany Sandstone (Meridian), . . . | | 340 |

### III. UPPER SILURIAN PERIOD.

| | | |
|---|---|---|
| VI. | Lower Helderberg Limestones and Shales (Pre-Meridian), . . . .<br>Onondaga Shales (Scalent), . . . | 295 |
| V. | Clinton Red and Gray Shales (Surgent), | 2000 |
| IV. | Medina Sandstones, } Levant | 665 |
| | Oneida Sandstones and Conglomerates, . . . } Levant | 460 |

### IV. LOWER SILURIAN PERIOD.

| | | |
|---|---|---|
| III. | Hudson River Slates<br>Utica Slates, . . } Matinal . . | 6000± |
| II. | Trenton and Calciferous Limestones (Auroral), | 2000± |
| I. | Potsdam Sandstone (Primal), . . . | —— |

The numbers assigned to the epochs and formations are those which were adopted by the First Pennsylvania Survey. The geographical names were first proposed by the New York State Survey, and have been generally made use of by geologists, wherever the strata composing these formations could be identified, throughout the Appalachian region. The New York nomenclature ended with the Catskill, and the names Pocono, Mauch Chunk, and Pottsville, were first suggested for the higher Pennsylvania rocks by Prof. Lesley, in 1875. The names placed in brackets were introduced by Prof. H. D. Rogers during the progress of the First Pennsylvania Survey. They have, however, never been generally adopted.

The areas in the region underlaid by the formations Nos. XII, XI and X, are generally easily defined by the topography which they produce, although in places no actual exposed outcrop may be found. The Pottsville conglomerate forms a rim around the coal basins, and the Pocono sandstone and conglomerate an outer rim, with a valley included between them eroded out of the Mauch Chunk red shale.

The thickness of the Pottsville conglomerate varies greatly. In Nesquehoning gap it measures 1155 feet (Fig. 3). Two miles to the east, midway between Nesquehoning gap and Mauch

Chunk, it is about the same thickness, while four miles to the west in the Nesquehoning Railroad tunnel[*] it measures only 880 feet, as given in the table of formations. In Locust Mountain gap, directly north of Tamaqua, about five miles a little south of west of the Nesquehoning Railroad tunnel, it measures 1280 feet. This variability in the thickness of the Pottsville conglomerate within short intervals, may show an unconformability between the underlying Mauch Chunk red shale No. XI (representative of the Sub-carboniferous or Mountain limestone), or an unconformability between the individual strata forming the conglomerate measures. It is more probable, however, that this change in thickness is due to an unevenness in the bottom of the water basin at the time that deposition took place, or to variable and changing water currents.

The facts at present obtained do not seem to be sufficient to attempt a final solution of the question. Prof. Lesley, in referring to this phenomenon, concludes that, "The variable thickness of the conglomerate must be discussed on one of two hypotheses: either, we must surmise extraordinary and unaccountable variations in the quantity of sand and gravel deposited on neighboring parts of the red shale sea bottom; or, we must apply the mechanical law, that the folding of a plastic mass shifts all parts of the mass to allow of its accommodation in a smaller space."

The thickness of No. XII declines rapidly towards Wilkes Barre. At the Red Ash colliery, which is 25 miles due north from the Nesquehoning R. R. tunnel, and immediately south of Wilkes Barre, the conglomerate measures but 97 feet. This change in the thickness of the conglomerate is as great in other directions, as shown by numerous sections made by the Geological Survey.

The variability in the thickness of the Productive Coal measures, and of their included coal beds, is relatively almost as great as that of the conglomerate; it would be impossible, to select any one section to illustrate the thickness, character, and succession of the coal beds and their included rocks throughout the region.

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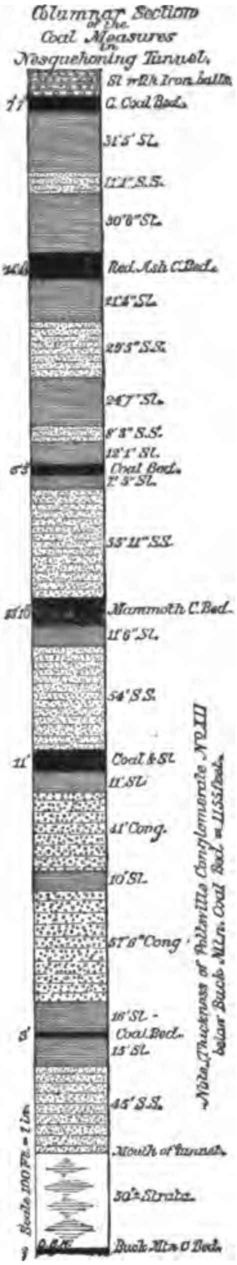
[*] The Rhume run tunnel back of the village of Nesquehoning is frequently called the Nesquehoning tunnel and was used solely for mining purposes; it must be distinguished from the Nesquehoning railroad tunnel through the Locust mountain, back of Lansford.

FIG. 3.



The non-parallelism of the anthracite beds, in many localities, is now proven beyond a question. In fact, it is doubtful whether the certain identification of any of the Carboniferous strata, over the entire coal region, can be accepted as at present determined, other than that of the Mammoth coal bed and the base of the Pottsville conglomerate No. XII. Until the relationship of the anthracite beds in the different districts is established, it is folly to attempt, as has often been done, to identify the anthracite coal measures with those in the Pennsylvania bituminous fields.

The accompanying section (Fig. 3), measured in the Nesquehoning or Rhume Run tunnel, is as representative of the anthracite measures as any which could probably be referred to. The Mammoth bed, which is 13 feet 10 inches thick in this section, changes, as do all the other coal beds, very much in thickness, in the number of separate benches of coal which it contains, and the amount of slate and poor coal which is included between the good coal benches or layers. Half a mile west of Summit Hill village, where the coal was first quarried in a surface cutting in 1792, the bed is about 50 feet thick; at one point, where a very careful measurement was made, the bed was composed of 21 separate benches of coal, having an aggregate thickness of 40 feet 3 inches, which were separated by 20 layers of slate, with a total thickness of 12 feet 10 inches. The average thickness of the bed east of Nesquehoning colliery is estimated to be 29 feet, with 23 feet of merchantable coal, and west of Rhume run to the Schuylkill-Carbon County line 55 feet, with only 27 feet of coal.

Between the county line and Tamaqua the average th of merchantable coal contained in the Mammoth bed i 27 feet, and the average thickness of the coal bed itse feet. In Colliery No. 9 of the Lehigh Coal and Nav Company, west of Summit Hill village, the Mammoth an average thickness of 50 feet and contains on the ave feet of merchantable coal. At one point in the colliery the bed has evidently been subjected to a local squeeze, i ures 114 feet thick and contains 106 feet of coal; while ness of 60 or 70 feet for the bed, with 40 or 50 feet of go contained in it, is not unusual at many points in this mi

The Red Ash bed, which is the bed most extensively in the Panther Creek valley next to the Mammoth, has a age thickness in the eastern and western ends of the b about 13 feet, containing 9 feet of coal, while in about o of the area of the basin near its centre the same bed has a age thickness of 9 feet with only 5 feet of coal.

In the Greenwood colliery workings, near Tamaqua, lowing measurements were made:

| Bed. | Average dip. | Coal bed. | Coal. | Per ce taken ou |
|---|---|---|---|---|
| G. | 57° | 3 ft. | 2 ft. | |
| F. | 57° | 12 " | 10 " | |
| E. | 51° | 20 " | 15 " | |
| D. | 57° | 9 " | 7 " | |
| C. | 57° | 8 " | 6 " | |
| B. | 57° | 6 " | 3 " | |
| A. | 55° | 10 " | 8 " | |

These facts, although local, are sufficient to show th variability of the anthracite coal beds and the impossi reporting a section of any one bed, which shall be an ave any considerable portion of the region. In the First R Progress of the Anthracite Survey a number of sections ar with a view of indicating, as near as possible, the averag ness of the coal measures, and the average thickness of beds contained, in a number of localities. A summary sections is given in the following table:

| Location of Sections. | Total Thickness of Coal Measures. | Total Thickness of Coal Beds. |
|---|---|---|
| Northern Field. | | |
| *Carbondale Basin,* Forest City colliery . . | 307′ 7″ | 19′ 6″ |
| " " near Carbondale . . . | 282′ 2″ | 13′ |
| *Lackawanna Basin,* near Scranton . . . | 633′ | 67′ |
| *Wilkes Barre Basin,* near Wilkes Barre . . | 867′ 3″ | 85′ 3″ |
| *Nanticoke Basin,* near Nanticoke . . . . | 918′ | 95′ 6″ |
| Eastern Middle Field. | | |
| *Black Creek Basin,* near Gowen . . . . | 558′ 1″ | 38′ 1″ |
| " " " near Ebervale . . . . | 369′ | 36′ |
| *Hazleton Basin,* Hazleton colliery . . . | 528′ 1″ | 81′ 4″ |
| Western Middle Field. | | |
| *Mahanoy Basin,* Ellangowan colliery . . | 767′ | 107′ 9″ |
| *Shamokin Basin,* Trevorton Estate . . . | 1408′ | 117′ |
| Southern Field. | | |
| *Panther Creek Basin,* near Tamaqua . . . | 2168′ | 126′ |
| *Pottsville Basin,* near Pottsville . . . . | 3097′ | 154′ |

The thickness assigned to the coal beds does not represent the thickness of merchantable coal contained in the beds, but the thickness of the beds, including the layers of slate and bony coal contained between the benches of good coal.

## COMPOSITION AND ORIGIN OF PENNSYLVANIA ANTHRACITE.

The analyses of anthracite coals, which have been reported up to within a few years, have been largely of small specimens collected in special parts of individual mines, and do not show, either the composition of the coal which can be commanded by the trade from the colliery, or the true chemical constitution of the coal in the bed, throughout the mine in which the individual specimens were obtained. The larger specimens which have been collected for fuel tests would seem to have been selected with too much discrimination; for, comparing them with more recent analyses which have been made privately and by the Geological Survey, they cannot constitute a criterion for the classification of the coals which they represent.

Thirty coals were recently collected by the survey in different parts of the region and analyzed,* not so much to show the composition of the coal contained in the different beds, as the fuel constituents of the coals shipped to market. In collecting these specimens, it was thought desirable to test the value of the judgment of the coal trade in discriminating between different coals, and in consequence the specimens were obtained from mines which were regarded by most consumers as producing coals of equal value. The specimens were collected from 100 to 200 tons of coal, as it was ready to be shipped to market, the amount collected in each case for analysis ranging from 100 to 200 pounds. The bulk of each specimen was then reduced by the ordinary methods used in sampling mineral products for qualitative and quantitative tests. The analysis of each individual specimen is recorded in detail on page xxxiv of the First Report of Progress of the Anthracite Survey. For present purposes it is not important to refer to the results in detail. A table of averages is given below, which shows the mean character of the coals mined from the more important beds of the Northern Field, in the vicinity of Wilkes Barre, the Eastern Middle Field, in the vicinity of Hazleton, the Western Middle Field, in the vicinity of Shenandoah, and the Southern Field, in the Panther Creek basin. The maximum of fixed carbon obtained in any one specimen was 88.2 per cent. as against 90 to 93 per cent., as has frequently been reported by different authorities. The minimum of fixed carbon was 78 per cent. as against 83 or 84 per cent., which has been generally considered to be about the minimum.

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* All the analyses referred to were made by Mr. Andrew S. McCreath, chemist for the Second Geological Survey of Pennsylvania.

## Composition of Pennsylvania Anthracite.

| No. of specimens. | Name of coal bed. | Name of coal field. | Chemical analysis.* | | | | | | Specific gravity. | Percentage of constituents of fuel. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water. | Volatile matter. | Fixed carbon. | Sulphur. | Ash. | Total. | | Fixed carbon. | Volatile combustible matter. | Fuel ratio, $\frac{C.}{V.H.—C.}$ |
| 3 | Wharton | Eastern Middle | 3.713 | 3.080 | 86.404 | .585 | 6.218 | 100 | 1.620 | 96.56 | 3.44 | 28.07 |
| 5 | Mammoth | Eastern Middle | 4.119 | 3.084 | 86.379 | .496 | 5.922 | 100 | 1.617 | 96.55 | 3.45 | 27.99 |
| 2 | Primrose | Western Middle | 3.541 | 3.716 | 81.590 | .499 | 10.654 | 100 | 1.654 | 95.64 | 4.36 | 21.93 |
| 5 | Mammoth | Western Middle | 3.163 | 3.717 | 81.143 | .899 | 11.078 | 100 | 1.657 | 95.62 | 4.38 | 21.83 |
| 2 | Primrose? (F)† | Southern | 3.008 | 4.125 | 87.982 | .506 | 4.379 | 100 | 1.584 | 95.52 | 4.48 | 21.32 |
| 2 | Buck Mountain | Western Middle | 3.042 | 3.949 | 82.662 | .462 | 9.885 | 100 | 1.667 | 95.44 | 4.56 | 20.93 |
| 1 | Seven Foot | Western Middle | 3.410 | 3.978 | 80.868 | .512 | 11.232 | 100 | 1.651 | 95.31 | 4.69 | 20.32 |
| 7 | Mammoth | Southern | 3.087 | 4.275 | 83.813 | .641 | 8.184 | 100 | 1.631 | 95.15 | 4.85 | 19.62 |
| 3 | Mammoth | Northern | 3.421 | 4.381 | 83.268 | .727 | 8.203 | 100 | 1.575 | 95.00 | 5.00 | 19.00 |
| | B Coal Bed ‡ | Loyalsock | 1.295 | 8.100 | 83.344 | 1.031 | 6.230 | 100 | —— | 91.14 | 8.86 | 10.29 |

* These analyses are arranged in the order of the percentage of fixed carbon in the fuel constituents.

† Called Red Ash bed in the Panther Creek basin.

‡ This coal, according to the classification referred to below, would be called a semi-anthracite, on account of the percentages of volatile matter and fixed carbon contained. The percentage of volatile matter is not as great, however, as that contained in many of the coals from the Shamokin and Lykens Valley districts, with which the Loyalsock coal favorably compares. The Shamokin and Lykens Valley coals are called anthracites by the trade, and on this basis the trade must consider Loyalsock or Bernice coal an anthracite.

One of the most extensively discussed questions connected with the region, and one about which the most unsatisfactory conclusions have been arrived at, has been the composition and classification of Pennsylvania anthracites. The original division of our Pennsylvania coals into anthracite, semi-anthracite, semi-bituminous, and bituminous was one founded largely upon their geographical distribution, although the supposed basis was the chemical composition of the coals. These names, as they have been indelibly fixed upon coals produced from special sections or individual mines, will always to some extent be made use of by the coal trade; they have, however, no scientific value. An interesting discussion of this subject was contributed to the Transactions* of the American Institute of Mining Engineers, by Dr. Persifor Frazer, and was subsequently published in Report MM. of the Second Geological Survey of Pennsylvania. As a result, the following classification† is suggested:

| Classes of Coals. | Ratio $\frac{C}{\text{Vol. H. C.}} : 1.$ |
|---|---|
| Hard-dry anthracite, | from 99: 1 to 12: 1 |
| Semi-anthracite, | from 12: 1 to 8: 1 |
| Semi-bituminous, | from 8: 1 to 5: 1 |
| Bituminous, | from 5: 1 to 0: 1 |

In arranging the coals under this classification, and others proposed, the accidental impurities, such as sulphur and earthy matter are disregarded in the analysis, and the fuel constituents alone considered. The fuel ratio of each coal, or the fixed carbon divided by the volatile hydro-carbon, is represented by the first term of the ratio expressed in the table. While this classification is probably the best which has been suggested for our Pennsylvania coals, and may be used provisionally as a scientific basis, the coals as at present graded by the coal trade could not be arranged under this or any other classification; and, I do not believe that we have sufficient data, at present at our command, to suggest a final arrangement, which might be considered a scientific rating of the coals, and which would be accepted by the coal miners, venders, and consumers.

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* Vol. VI, page 434.

† See Report AC, page 15.

The analyses given in the above table are of coals from all sizes (mixed) which are shipped from the different collieries. It is found in practice that after the coal is passed through the breaker and screened into different sizes for shipment, the purity of the different sizes, as regards fixed carbon and ash, is very different. This is indicated by the following analyses of specimens collected from the Hauto screen building of the Lehigh Coal and Navigation Company.

| Kind of Coal. | Water. | Volatile Matter. | Fixed carbon. | Sulphur. | Ash. | Total. | Color of Ash. |
|---|---|---|---|---|---|---|---|
| Egg, . . . | 1.722 | 3.518 | 88.489 | .609 | 5.662 | 100 | Light cream. |
| Stove, . . | 1.426 | 4.156 | 83.672 | .572 | 10.174 | 100 | Cream. |
| Chestnut, . | 1.732 | 4.046 | 80.715 | .841 | 12.666 | 100 | " |
| Pea, . . . | 1.700 | 3.894 | 79.045 | .697 | 14.664 | 100 | " |
| Buckwheat, | 1.690 | 4.058 | 76.918 | .714 | 16.620 | 100 | " |

These coals are separated into the different desired sizes according to the mesh of the screen over which they pass. The sizes noted in the above table passed over and through sieve meshes of the following dimensions:

| | | Inches. | | Inches. |
|---|---|---|---|---|
| Broken or grate, | through | 4 | over | 2.5 |
| Egg, | " | 2.5 | " | 1.75 |
| Stove, | " | 1.75 | " | 1.25 |
| Chestnut, | " | 1.25 | " | .75 |
| Pea, | " | .75 | " | .50 |
| Buckwheat, | " | .50 | " | .25 |

In preparing the coal for market, pieces of what is known as *Bony coal* are picked out as worthless and thrown on the dirt bank. The lustre of this coal is dull and it has a cannelly appearance; much of it is believed to be as good a fuel coal as that which is shipped from the same colliery to market. In fact, analyses recently made of three specimens* of this bony coal, from a certain colliery, proved them to contain more fuel constituents than the coal which was sold to the trade. It has been suggested that the *good* bony coal be called "*Cannel Anthracite.*"

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* See First Report of Progress, Anthracite Region, page 181.

The ashes of the anthracite coals have varying compositions. The following two analyses show the composition of the ash obtained from the red and white ash coals, which are mined, respectively, in the Panther Creek basin.

| | Red Ash. | | White Ash. | |
|---|---|---|---|---|
| Silica, . . . . . . . . . . . . . | 47.190 | | 48.250 | |
| Alumina, . . . . . . . . . . . . | 32.522 | | 36.177 | |
| Sesquioxide of iron, . . . . . . | 4.710 | | 3 290 | |
| Oxide of manganese, . . . . . . | trace. | | trace. | |
| Lime, . . . . . . . . . . . . . | 3.640 | | 1.950 | |
| Magnesia, . . . . . . . . . . | .965 | | .921 | |
| Sulphuric acid, . . . . . . . . | .712 | =Sulphur, . . .285 | .490 | =Sulphur, . .196 |
| Phosphoric acid, . . . . . . . . | 1.958 | =Phosphorus, .855 | .923 | =Phospho's, .403 |
| Titanic acid, . . . . . . . . . | .990 | | .750 | |
| Undetermined alkalies, etc., . . . | 7.313 | | 7.249 | |
| | 100.000 | | 100.000 | |

It would appear, as far as the investigation has proceeded in the anthracite region, that it is impossible to establish the geological relationship of the different coal beds from a study of the chemical analyses of the coals which they contain. From an attempt made in this direction,* it was found that greater variations, frequently, existed between the analyses of duplicate specimens than between those of specimens from different beds.

ORIGIN.—The existence of anthracite beds in Pennsylvania has never been satisfactorily explained. Two common and popular explanations are offered: first, that they are coked bituminous beds, the heat which has driven off the volatile matter being derived from intrusive rocks; but as no intrusive rocks have ever been discovered in the vicinity of the anthracite region, this explanation fails; second, that the necessary heat for the coking process was produced during the original plication of the region. As an answer to this latter explanation, it is only necessary to refer to the Belgian coal field, where the coal measures are not only highly corrugated, even more so than in the anthracite region, but the coals are bituminous,† containing high percentages of volatile matter. In considering both of these views, Prof. Lesley says:

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* See First Report of Progress of the Anthracite Region, page 184.

† The coals are reported, however, to contain less volatile matter, as greater depths are reached, in some cases becoming true anthracites.

"If anthracite coal be a coke, then it follows that it should have more ash than the coal from which it was made. This is not the case. It is difficult to find, after a careful search, a bituminous coal which runs so low in ash as the anthracite. And if 40 per cent. of hydro-carbons have been expelled to make anthracite, it should have 10 per cent. of ash to 6 in bituminous coal, which it certainly has not."

It is further suggested that the genesis of anthracite will probably be accounted for by an inquiry into the character of the original vegetation which went to form the coal beds.

While I do not think that we have all the data collected in the anthracite region necessary to solve this question, I believe we are in possession of sufficient facts to suggest its most probable solution. The change of the original vegetable deposit into anthracite has probably been effected to a great extent through a chemical process, by which a portion of the carbon has been oxidized, forming carbonic acid, at the expense of the combined oxygen, a portion of the combined hydrogen has been oxidized, forming water, and a portion of the carbon and hydrogen have been combined, forming marsh gas. The removal of the marsh gas (carburetted-hydrogen) in this way, as pointed out by Bischof, may convert bituminous coal into anthracite. Although heat would naturally aid this conversion, it might be the result of decomposition at ordinary temperature. The heat, which was unquestionably produced in the anthracite region during the plication of the strata, has possibly helped the process, and the water which was held by the strata in their semi-plastic condition at the time of their plication has probably been a potent aid. Daubrée has shown that a small amount of water raised to a temperature of between 300° and 400° C. will produce rock metamorphism.

The occurrence of an anthracite bed in the Loyalsock field, with a bituminous bed 60 feet vertically below it, where the strata are not plicated, but where they have all the structural peculiarities of the nearly horizontal strata in the Pennsylvania bituminous field, would seem to throw some light on this much vexed question, and lend support to the explanation here proposed.

The question has been asked, why should the coal beds of the anthracite basins be more oxidized than those of the bituminous fields. In reply, Prof. Lesley suggests this answer: "The undisturbed western coal measures consist largely of clay strata; those of the eastern coal measures consist in a much larger proportion of sand and gravel. This would favor the superior oxidation of the latter." Another important consideration is the fact that the circumstances, subsequent to and during the time in which the vegetable matter which composed the anthracite beds was accumulated, were probably more favorable to this oxidation. While the plication of the anthracite region would not seem to alone satisfactorily account for the origin of the anthracitic character of the coals, yet the time and circumstances under which it took place were probably more favorable to its formation than in the Belgian field. Many ideas connected with this suggested explanation have been thrown out by a number of noted English and American authorities, whom the author hopes to cite in a discussion of this subject to be published in the future, and who are not noted in this brief reference.

## MINING.

The general methods of opening the anthracite mines are various, depending largely upon the mode of occurrence of the coal bed. The early mines were mostly excavated out of the coal beds above water-level, in order to obtain natural drainage. This was accomplished, (1), by quarrying the coal at a natural outcrop, as at the old Summit Hill mines, and as is being done at present in the vicinity of Hazleton; (2), by water-level drifts, driven along the strike of the bed; (3), by water-level tunnels driven across the coal beds perpendicular to the strike [the drift and tunnel plans are illustrated by many of the abandoned mines, and those which are still being worked in Schuylkill and south-western Carbon Counties]; (4), by slopes driven down the dip of the bed; and (5), by vertical shafts.

Between the lowest point of outlet to the mine and the outcrop of the coal bed, the coal is worked from nearly horizontal gangways driven along the strike of the bed; the coal between any two gangways being worked out from the lower one, by the ordinary pillar and breast system. In high dipping beds the lift, or distance along the dip of the bed between any two gangways, varies from 75 to 100 yards. In beds with low dips the positions of the gangways are dependent upon local conditions. The size of the gangways, pillars, and breasts or chambers varies according to circumstances.

There are many modifications in the details of the pillar and breast system, that most generally employed in the region, which are to some extent dependent upon the choice of the mine superintendent, but more generally are governed by the lay of the coal bed, its thickness, and the constitution and character of the enclosing rocks.

The percentage of the amount of coal which is originally contained in the ground before mining is commenced, which is left in as pillars for roof support, and the percentage which is taken out, is variable. In the high dipping beds of the Panther Creek basin, between Tamaqua and Mauch Chunk, the percentage of coal which has been taken out of the individual mines, from their original opening to the present time, varies between 51 and 69 per cent.; while for the entire basin, between the years 1820 and 1883, the amount of coal removed was 59 per cent., and that left in the pillars and other portions of the mines was 41 per cent. of the original contents.

The better and more economical methods of mining which have been introduced into this basin during the past few years have resulted in taking out of the mines, for the years 1881 and 1882, 70 per cent. of the original coal contained. In other portions of the region, notably in limited sections of the Northern Coal Field, where the beds do not dip as steeply as in the Southern Field, and where the conditions for more economical mining generally obtain, as much as 80 or even 85 per cent. of the coal originally contained is taken out of the mines.

This percentage does not represent the amount which is converted into commercial fuel, since the coal has to be broken into market sizes and has to be freed from the slate and bad coal which is mixed with the good coal when sent from the mine to the breaker. This preparation of coal for market is attended with great waste. In the Panther Creek region, between the years 1820 and 1883, 32 per cent. of the coal originally contained in the worked areas was sent directly from the mines and breakers to the dirt banks as waste, and only 27 per cent. was converted into fuel coal. During the years 1881 and 1882 the waste coal only amounted to 24 per cent. of the original contents, and as much as 46 per cent. was converted into fuel coal. This shows that from 1820 to 1883 of the 59 per cent. of the original contents of the coal beds which was taken out of the mines, more than half (56 per cent.) was thrown on the waste heap, while a little less than half was converted into fuel. During the years 1881 and 1882, of the 70 per cent. of the original contents taken out of the mines, only one-third (34 per cent.) was thrown on the waste heap and two-thirds were converted into fuel. This gain is due to two causes: first, to mechanical improvements and greater economy in breaking the coal; and, second, to the present consumption of the smaller sizes of coal which were formerly thrown away on the dirt bank.

The waste in the preparation of coal is due to breaking, to screening, and to attrition while the coal is passing from the shutes to the pockets and market cars. This waste is dependent upon so many varying conditions connected not only with the construction and working of the breaker, but upon the character of individual coals, that it is impossible to give an average for the region. In the Shenandoah district the waste in breaking and preparing the Mammoth coal at a number of collieries was found to be 15 per cent. In the vicinity of Wilkes Barre, in preparing coal from the Red Ash bed at several collieries, but 6 per cent. of waste was obtained, while in preparing coal from the Baltimore or Mammoth bed about 11 per cent. of waste resulted. In the Shamokin district the waste from breaking and screening is reported in some cases to be as high as 25 and 30 per cent.

The utilization of the waste coal which is now thrown on the dirt or culm bank is a question of great economical importance to this region. Several methods have been suggested for preparing the fine coal and manufacturing it into blocks of various sizes, none of which have yet come into general use. While it would seem to be practical, to manufacture such fuel under particularly favorable conditions, I believe that the final solution of the problem is not the manufacture of the waste coal into forms which would make it a possible fuel, with the same conditions of combustion under which the various sizes of broken anthracite are used, but rather to manufacture a special form of grate and furnace where the waste coal can be consumed in its present form. Of course, where the culm is filled with poor coal and slate, this must be removed in order to obtain the best results. In other words; the design of the furnaces must be adapted to the existing form of the coal, and not the form of the coal adapted to the existing forms of furnaces. I believe the most practical results in making use of waste coal, have been obtained by Mr. J. E. Wootten, General Manager of the Philadelphia and Reading Railroad, who has designed a special form of grate and furnace for its consumption in its natural condition.

## STATISTICS OF PRODUCTION.

The economical importance of the anthracite coal fields can be better realized from an inspection of some of the statistics connected with their production, rather than from a study of the brief description, which has been here attempted, of their natural characteristics. During the year 1883 the estimated shipment of bituminous coal in Pennsylvania was 24,000,000 tons, and of bituminous coal in all the other States about 40,000,000 tons, while the reported shipment of Pennsylvania anthracite was 31,793,027 tons.* The shipment of anthracite was 79 per cent. of the total coal shipment in all the other States, and 33 per cent. of the total shipment of the United States, including both Pennsylvania bituminous and anthracite coal. During the same year the estimated production of fuel-coal throughout the World was 385,000,000 tons, of which, it is perceived, the shipment of the anthracite region was 8 per cent. During the year 1883, according to the Mine Inspectors' Reports, there were 386 mines in operation in the region, producing in the aggregate 33,955,831† tons. In a number of instances the coal from several mines is prepared at the same breaker and mixed, prior to shipment; so that, according to the report of Mr. John H. Jones, accountant for the transportation companies, there were only 357 shipping collieries. In 1883 the largest producing colliery was Breaker No. 2 of the Susquehanna Coal Company, in the vicinity of Nanticoke, its total production for the year being 420,543.7 tons.

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* Includes Loyalsock shipment (80,124 tons). Ton equals 2,240 pounds.

† Includes Loyalsock production (84,376 tons).

The division of the field by the coal trade into regions and districts, with the amount of coal produced in each district, is given in the following table:

| Name of District. | Number of producing Mines. | Production. |
|---|---|---|
| WYOMING REGION. | | |
| Loyalsock, | 1 | 84,376.00 |
| Carbondale, | 21 | 1,728,858.00 |
| Scranton, | 40 | 4,725,315.00 |
| Pittston, | 39 | 2,173,144.50 |
| Wilkes Barre,<br>Plymouth, | 59 | 7,400,095.80 |
| Totals, | 160 | 16,111,789.30 |
| LEHIGH REGION. | | |
| Green Mountain, | 5 | 429,555.30 |
| Black Creek, | 24 | 2,455,091.65 |
| Hazleton, | 15 | 1,443,448.00 |
| Beaver Meadow, | 12 | 1,236,005.60 |
| Totals, | 56 | 5,564,100.55 |
| SCHUYLKILL REGION. | | |
| East Mahanoy, | 17 | 1,432,837.45 |
| West Mahanoy, | 56 | 5,174,693.55 |
| Shamokin, | 21 | 1,439,567.35 |
| Panther Creek, | 12 | 825,185.70 |
| East Schuylkill, | 24 | 331,569.35 |
| West Schuylkill, | 30 | 428,310.55 |
| Lorberry, | 4 | 167,191.35 |
| Lykens Valley, | 6 | 1,266,912.70 |
| Totals, | 170 | 11,066,268.00 |
| Grand Totals, | 386 | 32,742,157.85* |

* This is less than the total production (33,955,831 tons) obtained from the Mine Inspectors' reports. In the case of some of the individual mines, it has been impossible to discriminate between the shipment and the production.

The difference between the production as given by the Mine Inspectors and the shipment as given by Mr. Jones, is 2,162,804 tons, which represents the amount of coal consumed at and in the vicinity of the collieries.

The coals which are shipped from these different districts have been generally divided by the coal trade into eight classes, as follows:

(1) Hard white-ash coal, that shipped from all the collieries (53) in the Lehigh region, from 14 collieries in the East Mahanoy district, from 34 collieries in the West Mahanoy district, from 9 collieries in the Panther Creek district, and from 6 collieries in the East Schuylkill district.

(2) Free-burning white ash, that shipped from the Loyalsock basin, from all the collieries in the Carbondale (26) and Scranton (41) districts, from 27 collieries in the Pittston district, from 30 collieries in the Wilkes Barre district, from 15 collieries in the Plymouth district, from 1 colliery in the East Mahanoy district, from 21 collieries in the West Mahanoy district, from 8 collieries in the East Schuylkill district, and from 17 collieries in the West Schuylkill district.

(3) Schuylkill red ash, that shipped from 1 colliery in the West Mahanoy district, from 1 colliery in the Panther Creek district, from 5 collieries in the East Schuylkill district, and from 3 collieries in the West Schuylkill district.

(4) Shamokin, that shipped from 19 collieries in the Shamokin district.

(5) Lorberry red ash, that shipped from all the collieries (4) in the Lorberry district.

(6) Lykens Valley red ash, that shipped from all the collieries (6) in the Lykens Valley district.

(7) Trevorton, that shipped from 2 collieries in the Shamokin district.

(8) Wyoming red ash, that shipped from 1 colliery in the Pittston district, from 6 collieries in the Wilkes Barre district, and from 7 collieries in the Plymouth district.

Of the total coal shipped 49.08 per cent. was sent from the Wyoming region, 19.23 per cent. from the Lehigh region, and 31.69 per cent. from the Schuylkill region. This coal is now carried to market by seven large transporting companies, as given in the following table, with the number of tons carried by each company.

| INTEREST. | TONS, 1882. | TONS, 1883. |
|---|---|---|
| Philadelphia and Reading Railroad, | 7,000,113 | 10,487,003 |
| Lehigh Valley Railroad, | 5,933,740 | 6,271,773 |
| Central Railroad of New Jersey, | 4,211,052 | *1,745,399 |
| Delaware, Lackawanna and Western Railroad, | 4,638,717 | 5,079,123 |
| Delaware and Hudson Canal Company, | 3,203,168 | 3,512,971 |
| Pennsylvania Railroad Company, | 2,332,974 | 2,773,419 |
| Pennsylvania Coal Company, | 1,469,821 | 1,541,145 |
| New York, Lake Erie and Western R. R., | 330,511 | 382,194 |
| Totals, | 29,120,096 | 31,793,027 |

Of the total shipment from the region, 13,148,185 tons were sent to the Eastern competitive points at tide water, the remaining portion being sold to the line trade. This large percentage (41), of the total shipment, sent to the above points makes it necessary for the coal transportation companies to regulate the production of the region through a board of control, in order to restrict the production within the limits of the demand, and to make it possible to mine and transport coal without direct loss either to the miners or railroads. In the year 1883 the production was restricted by the mining being stopped during 60 days, scattered through the year.

The details of the distribution for 1882 are shown in the following table:

| | |
|---|---|
| To Pennsylvania, New York and New Jersey, | 19,957,789 |
| To the New England States, | 5,064,775 |
| To the Western States, | 2,213,107 |
| To the Southern States, including Delaware, Maryland and the District of Columbia, | 1,168,730 |
| To the Pacific Coast, | 49,065 |
| To the Dominion of Canada, | 616,875 |
| To Foreign ports, | 49,735 |
| Total, gross tons, | 29,120,076 |

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* Is for five months only; after June 1st the tonnage was figured in with that of the Philadelphia and Reading Railroad as lessee.

The largest mining company is the Philadelphia and Reading Coal and Iron Company, which is operated in conjunction with the Philadelphia and Reading Railroad Company. The production of this company during 1883 was 4,582,667 tons. The collieries leased by the company during the same year produced 1,491,465 tons, making an aggregate of 6,074,132 tons. The cost to this company per ton for mining in 1883 was $\$1.49\frac{5}{10}$.

The total shipment of coal from the anthracite region, reported by Mr. P. W. Sheafer up to 1868 and by Mr. John H. Jones since then and up to the end of 1881, was 438,580,394 tons. It is estimated that the total production at the mines during the same period was 478,052,629 tons. If to this be added the production of the mines, as reported by the Mine Inspectors, for the years 1882 and 1883, the total production of the region from the commencement of mining up to 1884 would be 543,205,150 tons.

It is difficult to realize this tonnage. Estimating that, on an average, a ton of coal (2,240 pounds) in the bed contains 25 cubic feet, this tonnage would form a solid wall 100 feet wide and 100 feet high for a distance of 257 miles; or it would form a solid wall along the line of the P. & R. R. R. between Philadelphia and New York 100 feet wide and over 286 feet high. If a similar estimate be made of the coal in broken sizes, as it is shipped to maket, on a basis of 40 cubic feet to the ton, it would form a wall 100 feet wide and 100 high for 411 miles, or along the railroad between the two cities above referred to, 100 feet wide and over 458 feet high.

During the year the estimated value at the mines of a ton of anthracite was $2.10; so that the aggregate spot value of the anthracite coal produced during that year in Pennsylvania would be $71,307,245. The spot value of the bituminous coals, at all the mines in the United States during the same year, on the basis of $1.20 per ton, would be $76,800,000, while, according to Mr. Albert Williams, in charge of the mining statistics of the United States Geological Survey, the total value of the gold and silver mined during the same year in the United States was $71,300,000.*

As to the exhaustion of special parts of the coal fields or of the entire region, nothing can be added to my reference to the subject in the First Report of Progress, Anthracite Region,* as follows:

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* Based upon the estimate of J. J. Valentine, Esq., Supt. Wells, Fargo & Co.'s Express.

"The Survey has at present no data upon which to base any conclusion which would be of practical value. I have never made an estimate as to the duration of the Anthracite Coal Fields, because the Geological Survey has not advanced sufficiently to enable me to do so. In fact, the Panther Creek basin, which covers about one-fortieth of the entire area of the field, is the only locality where any measurements have been completed by the Survey as to the amount of coal taken out, or that which still remains to be mined."

"Mr. P. W. Sheafer, who has probably given the subject more careful consideration than any one else, has named something less than two hundred years as the time when the Anthracite Fields will be practically worked out. Mr. Sheafer has made a general statement that the field originally contained about 25,000,000,000 tons of coal. Up to January 1st, 1883, I have estimated that the total production amounted to 509,333,695 tons. It has been generally thought that but one-third of the coal contained in the area which has thus far been mined over in the entire region, has been consumed as fuel, so that up to last January an area has been exhausted which originally contained about 1,500,000,000 tons, 23,500,000,000 tons remaining untouched. If this same proportion of production to original contents be applied to that which still remains, about 8,000,000,000 tons would represent the possible future production."

"According to the Mine Inspectors' report, there was produced last year (1882) 31,281,066 tons. If this production should remain constant for all future time, the field would be exhausted in a little over two hundred years."

"Such a conclusion is quite untenable, for our yearly production is rapidly increasing. In 1870 there was shipped from the region 16,192,181 tons, and in 1880, 23,437,242 tons. The abrupt exhaustion of the coal fields is a practical impossibility, nor is it reasonable to suppose that, if, on an average, for every ton of coal won there are two lost, this will be the practice in future mining."

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